+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

Marcus Spectrum Solutions, LLC

Consulting Services in
Radio Technology and Policy
8026 Cypress Grove Lane
Cabin John, MD 20818 USA
February 2, 2018

VIA ECFS **EX PARTE**

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW, Room TW-A325
Washington, DC 20554

Re: Dockets 18-21 Draft NPRM

Dear Ms. Dortch:

These comments represent the views of Marcus Spectrum Solutions LLC ("MSS") and not necessarily the views of any of its clients. MSS is the consulting practice of Dr. Michael Marcus, whose qualifications are well known to the Commission. While at FCC, he proposed and directed the Docket 94-124 rulemaking that opened the 60 GHz band which has since expanded to 57-71 GHz and proposed and had an active role in the Docket 02-146 rulemaking that created the 70/80/90 GHz bands as well as the "licensed light" concept for its licenses.[1]

This draft NPRM was released yesterday. Due to pending overseas travel we are submitting these ex parte filing promptly which summarizes my major concerns. MSS applauds the Commission for considering these proposals to move the upper boundary of service rules which has been at 95 GHz since 2003.

Proposals ratify the "balkanization" of bands above 95 GHz imposed by passive allocations without serious discussion of win/win sharing.

Para. 8 of the draft notes that our previous comments to the Commission mentioned the "need for large contiguous spectrum blocks for terrestrial fixed service"[2] but then this topic is ignored in the remainder of the draft. We believe this issue needs explicit attention in the final NPRM.

All spectrum above 48 GHz is subject to G/NG (FCC/NTIA) sharing with a few very minor exceptions. Thus all this spectrum needs collaboration, consultation and

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[1] *See* http://www.marcus-spectrum.com/page5/index.html
[2] Marcus Spectrum Solutions Comments, GN Docket No 14-177, at 22-24 (filed Sept. 30, 2016).

+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

coordination with NTIA. But due to the physics of upper spectrum[3], passive allocations have a much greater impact than at lower bands: there is a much greater fraction of spectrum dedicated to passive bands than in lower spectrum and the passive spectrum allocations chops up or balkanizes the remaining spectrum without passive allocations in a way with not comparable equivalent in lower spectrum. This is the actual reason for the odd chopped up band structure proposed in para. 30:

> "Consequently, we are seeking comments on proposed rules for fixed point-to-point operations in 36 gigahertz of spectrum in the 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands"

Why is this important? One promising use of this band is for alternatives to fiber optics in places where fiber optic installation is too expensive or in conditions when timely installation of fiber is not practical. This could include restoration of damaged fiber paths in disasters such as earthquakes with ground rupture pending the long term repair of the fiber. mmWave radio technology is not *generally* competitive with fiber on an equipment cost basis, but it could serve niche applications where fiber installation is not viable and offers network planners new flexibility for both rapid service restoration in emergencies, rapid installation for unexpected needs, and for links in locations with very high fiber installation costs.

But to compete with fiber large bandwidths are needed. The distribution of passive bands above 95 GHz chops up or "balkanizes" the available spectrum. NTIA clings to a very narrow reading of U.S. Allocation Table[4] US246 which states that "No station shall be authorized to transmit .." and then gives a list of bands ranging from 73 MHz to 273 GHz. However, a careful reading shows that US246 itself has its own two footnotes which make exceptions for the 608-614 MHz Radio Astronomy band where FCC and NTIA have agreed on an alternative protection scheme.

While the "No station shall be authorized to transmit"-approach has technical merits for bands below 50 GHz where modest size antennas can not focus power to narrow beamwidths and where anomalous weather-related propagation, *e.g.* ducting and sporadic E modes, can result in intermittent long range excursions by radio signals, these are not real factors above 95 GHz. In addition, the atmospheric absorption of radio power at these frequencies adds another safeguard against interference to passive satellites since the path loss, especially at low angles, far exceeds the free space path loss at lower frequencies.[5] Sharing of terrestrial point-to-point use with passive radio astronomy or environmental satellite should be possible in most of the geographic area of the US with

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[3] *See* National Research Council, *Spectrum Management for Science in the 21st Century*, 2010 (https://www.nap.edu/catalog/12800/spectrum-management-for-science-in-the-21st-century)

[4] 47 C.F.R. 2.106

[5] Recommendation ITU-R P.676-11(09/2016) Attenuation by atmospheric gases (https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.676-11-201609-I!!PDF-E.pdf)

+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

restrictions on power and elevations angles which depend on locations. In particular, ITU-R RS.2017 gives the maximum undesired signals environmental satellites can tolerate, the service rules should conservative prevent FCC authorized transmitters form exceeding a fraction of this limit.

The main reason to avoid these bands is a bureaucratic one with FCC/NTIA coordination on revising US246, **not a technical issue** in protecting key satellite systems. The balkanized band plan in para. 30 precludes broadband fiber optic-like capacity Fixed systems. MSS urges FCC to modify the proposals in the draft to allow sharing of the passive bands in 100-151.5 GHz subject to strict licensing criteria that protect all passive users. Such licensing criteria should limit band use near the handful of radio astronomy facilities using these bands and should limit powers and elevation angles to protect passive satellites. **There is no fundamental need to continue the present wording of US246 in the bands in this proceeding.** The US has the option under ITU Radio Regulation 4.4 to act outside of ITU allocations if it assures that spectrum use of other ITU signatories meeting allocations conditions are protected.[6] An alternative to the present US246 is given in Attachment I.

The Commission has just created a new Office of Economics & Analytics. Perhaps this new office should look at the economic benefits that would result from making a contiguous block of spectrum available in most of the US under parameters that protect both incumbent and future passive users.

RF Exposure Limit Issue

Para. 80 raises the issue of the present lack of any numeric RF exposure safety limit above 100 GHz. But it then concludes,

> "We propose that the Commission make no changes to its present rules limiting human exposure to RF energy until it considers the broader issues brought forth in its *RF Inquiry"*

This "*RF Inquiry"* is identified in fn 193 as "ET Docket Nos. 13-84, 03-137". Figure 1, below, shows a screen shot from EDOC on the status of this docket:

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[6] "Under No.4.4 of the ITU Radio Regulations, administrations may assign frequencies in derogation of the ITU Table of Frequency Allocations "on the express condition that harmful interference shall not be caused to services carried on by stations operating in accordance with the provisions of the Convention and of these Regulations." Section 4.1.3.3.A *NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management ("Redbook")*
(https://www.ntia.doc.gov/files/ntia/publications/redbook/2015-09/4a_15_9.pdf)

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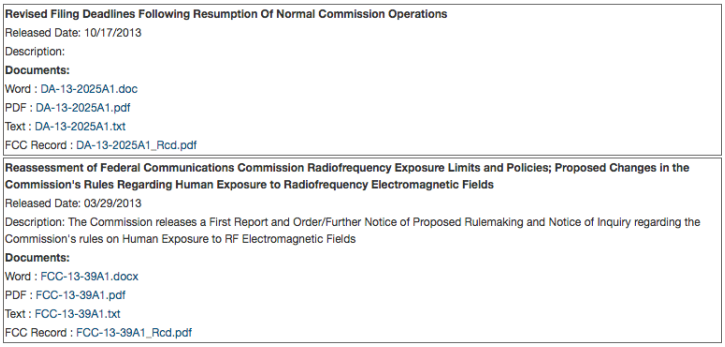
+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com



Revised Filing Deadlines Following Resumption Of Normal Commission Operations
Released Date: 10/17/2013
Description:
Documents:
Word : DA-13-2025A1.doc
PDF : DA-13-2025A1.pdf
Text : DA-13-2025A1.txt
FCC Record : DA-13-2025A1_Rcd.pdf

Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies; Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields
Released Date: 03/29/2013
Description: The Commission releases a First Report and Order/Further Notice of Proposed Rulemaking and Notice of Inquiry regarding the Commission's rules on Human Exposure to RF Electromagnetic Fields
Documents:
Word : FCC-13-39A1.docx
PDF : FCC-13-39A1.pdf
Text : FCC-13-39A1.txt
FCC Record : FCC-13-39A1_Rcd.pdf

Figure 1: Docket 13-84 status from EDOCS

Simply put, **this is not a very active proceeding**. It involves a large number of complex issues. Many of them possible outcomes are controversial. The issue of *some* numeric limit for RF exposure above 100 GHz is not controversial. The Commission's present RF safety limits are derived, with some modifications, from an underlying IEEE standard[7] which actually has recommended levels up to **300 GHz**.[8] Thus there is ample precedent to extrapolate up above 100 GHz. (Note that when the present 100 GHz limit for numerical exposure was adopted, FCC service rules did not reach beyond 76 GHz.)

The issue here is not the precise level of the limits which probably won't matter much to equipment designers since the main emissions will not be aimed at people. A conservative level here would be better than the present absence of any exposure limit. Why? Where there is an FCC mandated exposure limit regulatees can point to that in case of problems with local governments on zoning or permitting and claim federsal preemption. Also such a limit discourage frivolous litigation claiming a danger form emissions. All lower bands have such numerical limits. The absence of any such limit above 95 GHz is another externality that discourages capital formation for this technology by increasing litigation risks. MSS urges the Commission to propose a conservative extrapolation of the existing limit based on the underlying IEEE standard.

Given no public schedule for the resolution of Docket 13-84, the complxity of that proceeding and the controversies associated with it, the deferral of the issue to that proceeding is simply not credible.

Experimental licensing issues

Para. 61-79 addresses proposed changes to the Experimental Radio Service, Part 5 of the Commission's Rules. While the proposed changes would not cause any harm, they also do not solve any real problems. MSS has helped many clients apply for experimental

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[7] American National Standards Institute (ANSI), *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to* ***300 GHz***, , ANSI/IEEE Std C95.1-1992, Sections 4.1 and 4.2 (emphasis added)
[8] See *1st R&O, FNPRM & NOI*, Docket 13-84, 2013 at para. 11 (https://apps.fcc.gov/edocs_public/attachmatch/FCC-13-39A1_Rcd.pdf)

+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

licenses above 95 GHz, recently obtaining perhaps the highest license ever issued at 1050 GHz for The University at Buffalo SUNY.[9]

The biggest problem with experimental licensing today is with NTIA coordination. Since essentially all this spectrum is G/NG shared, all Part 5 applications are sent to NTIA. Due to a quirk of the 1990s software still used, only the application form gets sent, not any supplemental statements which usually accompany applications and give details of the test plan and explanations of why the test will not impact federal spectrum use. But it is not clear if this even matters.

NTIA staff send the applications the IRAC Frequency Assignment Subcommittee (FAS) where representatives of various agencies consider it. For all practical purposes, FAS uses a classic "fraternity blackball scheme" where a negative vote from any member basically kills the application. There is not evidence that NTIA leadership now exerts any oversight of the process before they send a rejection to FCC to be forwarded to the applicant. (When the general FCC/NTIA license coordination process goes smoothly with thousands of license a year, most of these are routine actions for Part 90 and Part 101 licenses with clear precedents and criteria. Our concern here only applies to the special case of experimental license coordination above 95 GHz, not the more general coordination case.)

At present some components and subsystems for bands above 95 GHz are available but not at every possible frequency. A unit that is in limited production at these frequencies might cost $10,000-$100,000. But if an experiment has to be moved to a nearby band due to NTIA/IRAC objections, the equipment cost for the experiment could increase by a factor of more than 10 since custom design and fabrication is needed. Note that this is for basic experiments, not for prototypes of production systems. Often basic experiments are needed to confirm details in the basically virgin spectrum before equipment can be designed for a bands for long term use. The present NTIA position on US246 in this spectrum either delays experiments or puts an effective surcharge on their cost in order to avoid US246 bands regardless of whether there is actually an interference potential to the protected bands. We also note that NTIA coordination has been difficult for even terrestrial radio propagation experiments to verify the details of such propagation to advance the science of radio technology.[10]

We have experienced extensive delays on experimental licenses to do basic terrestrial propagation experiments with no sky illumination in areas without any radio astronomy facilities![11] Thus there is a legitimate need to perform experiments in passive bands even if there is not long term intent to use such bands. Yet repeatedly NTIA has rejected such

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[9] WM9XGE

[10] *See* Special condition 3 of license Call Sign: WI2XVS forbidding use of 100-102 GHz for radio propagation experiments at Brown University (https://apps.fcc.gov/els/GetAtt.html?id=194015&x=.)

[11] *See* Files 0231-EX-CN-2017 and 0154-EX-CM-2017

+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

applications and they have only been granted after time consuming FCC staff intervention.

One IRAC/FAS member even e-mailed us after MSS requested a conversation on such an issue and wrote:

> "While I would have no difficulty in speaking to you on this subject, the problem is one of policy. It is (agency X) policy to not allow ANY emissions in ANY bands allocated to exclusive passive use such as given in US246 and RR No. 5.340. For this reason I had no choice but to object to the subject application. In fact, had (military agency) applied for the STA through one of the MILDEPS, (agency X) would have objected to that as well."

After FCC staff intervention with NTIA, the experimental license requested was finally granted after a delay that caused the applicant to miss a milestone for its military contract.

The second sentence of Section 7(a) of the Communications Act of 1934 as amended states

> "Any person or party (other than the Commission) who opposes a new technology or service proposed to be permitted under this chapter shall have the burden to demonstrate that such proposal is inconsistent with the public interest."

MSS believes that FCC should interpret this clear provision to apply to NTIA coordination of experimental license applications for new Spectrum Horizons technology. While NTIA is coequal to FCC under the terms of Sections 305 and 902, the terms of Section 7(a) are quite clear and can not be overridden by the 2003 FCC/NTIA Memorandum of Understanding.[12] If NTIA wants to object to an experimental license, it should have the burden of proof to show that the license will actually impact present operation of actual federal systems. There are ample provisions for NTIA to make a classified showing to FCC staff and leadership if it necessary to make such a point "that such proposal is inconsistent with the public interest" not just that an IRAC/FAS member objects.

Finally, while para. 4 acknowledges the provisions of § 5.83(b) that experimental licenses are "subject to cancellation at any time without notice or hearing", the topic is not discussed elsewhere in the NPRM. Real investors do not want to invest in R&D and production of new technology equipment that is subject to such a provision. Real customers would be reluctant to buy equipment under such terms unless the cost was very modest. The proposed "Subpart I—Spectrum Horizons Experimental Radio Licenses" should be amended to exempt such licenses from the terms of § 5.83(b) in order to establish at least a minimum level of administrative certainty for developers in this badn and their customers. This does not have to include the usual "expectation of renewal" that is basic to many licenses in other radio services, but should at least include a license term long enough to allow equipment cost amortization for purchasers. Similarly

[12] https://apps.fcc.gov/edocs_public/attachmatch/DOC-230835A2.pdf

+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

manufacturers need assurances that equipment developed with expensive R&D will have market access for a minimum period.

US246 must be revised to focus on protecting passive systems in this spectrum not banning all transmitters

As explained *supra* NTIA uses the present wording of US246 as a rationalization for banning use of large parts of spectrum and balkanizing that which is left. NTIA has repeated tried to block even experimental license applications explicit permitted under the terms of §5.85(a)(2)[13] regardless of their interference potential to federal systems.

The solution of this is either a major policy change within NTIA or a revision of US246 to make clear that the "No station shall be authorized to transmit" provision only applies to bands below some cut off limit, say 50 GHz. Stations authorized above that limit should be on a strictly secondary noninterference basis to the primary passive service with prospect to both current and future uses and should be subject to strict licensing rules on power and elevation angle of antenna beam to create acceptable signals at the location of passive receivers either at radio astronomy sites or on passive satellites. But in reality such a revised rule will produce the ability for high data rate fiber optic-like capacity systems as most locations in the US and enhance US technical competitiveness.

Maintain level playing field for Fixed and Mobile services

All the allocations above 95 GHz for Fixed communications has a coprimary Mobile allocation. The Commission should learn from the ongoing 5G rulemaking that it is difficult to untangle these services unless care is taken to look at the long term when inital service rules are adopted. Indeed, the coprimary allocation implies that if Fixed users start using the band, they will have an expectation of protection from later users including mobile users under the "first in time, first in rights" doctrine:

> "The Commission's longstanding "newcomer" policy mandates that a newcomer (i.e., a party constructing a new or modified facility) is responsible, financially or otherwise, for taking steps necessary to eliminate objectionable interference to existing stations. This policy has been applied to a variety of services."[14]

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[13] 47 C.F.R. 5.85(a)(2): "Applications to use any frequency or frequency band exclusively allocated to the passive services (including the radio astronomy service) must include an explicit justification of why nearby bands that have non-passive allocations are not adequate for the experiment. Such applications must also state that the applicant acknowledges that long term or multiple location use of passive bands is not possible and that the applicant intends to transition any long-term use to a band with appropriate allocations."

[14] 3rd R&O, MM Docket No. 93-177, 2013, at para. 4 (https://transition.fcc.gov/Daily_Releases/Daily_Business/2013/db0816/FCC-13-115A1.pdf)

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mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

At present there is no mobile interest in spectrum above 95 GHz, except perhaps for backhaul. But there was no mobile interest above 24 GHz a decade ago! Now 5G is one of the industry's and Commission's high priorities! The NPRM should allow for the possibility that history may repeat itself in a decade or two and mobile use may become attractive above 95 GHz. If careful attention is paid now we can create a level playing field for BOTH fixed and mobile services in these new bands without discouraging the Fixed uses that are now nearing commercial practicality We have several suggestions to effect that:

1. Instead of making the new Fixed rules part of Part 101, add a new subpart to the new Part 30, "Upper Microwave Flexible Use Service" to emphasize the Commission's interest in a level playing field between services.

2. Add an new US footnote to all bands with new Fixed service rules indicating that while they are coprimary with Mobile, not all the traditional aspects of coprimary status apply. In particular, if and when mobile rules are adopted for these bands Fixed users may have to make some accommodations for Mobile use.

3. Create a "safe harbor" for Fixed users in the new bands with Fixed service rules and coprimary Mobile allocations. Fortunately, this is much easier above 95 GHz than it is in lower bands due to the ability of modest size antennas to focus transmitted power more effectively due to the small wavelengths involved. In addition, Mobile use differs from Fixed use in a key way: Mobile systems need to illuminate the ground while Fixed users need to only illuminate their intended receive antenna. Interservice interference to mobile is basically caused by excess power flux density on the ground from Fixed transmitters. While the NPRM provisions in the proposed §§ 101.113,115 effectively limit effective radiated power ("erp"), at this upper spectrum it would be more efficient to limit pfd on the ground in order to prevent interference to future mobile systems. But such a limit may be overly burdensome, so a compromise to limit initial burden but maintain flexibility would be to create a safe harbor for Fixed users with an maximum pfd on the ground or a modest height above the ground, say 3m. Fixed users that meet this limit would be guaranteed traditional comprimary status while those that did not would be subject to the proposed US footnote discuss above.

Non-communications uses such as "terahertz spectroscopy"

A quick Google search or look in Wikipedia will show that "terahertz spectroscopy" actually "is a thing". Indeed products are in serial production both in the US and overseas and are clearly being marketed in the US, often under questionable compliance with Commission policies. This technology is used to examine materials to confirm their structural integrity and for other applications in material science. It is used in factories to monitor in real time the production of products such as plywood to improve process control and product quality. The former NASA Space Shuttle program funded several applications of this technology and used them to insure the integrity of rockets and the

+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

shuttle itself.[15] While the NPRM draft includes an unlicensed section in para. 51-60, this does not consider the need of this promising radio technology.

Terahertz technology use is very low power with typical ranges in the centimeter range. However, it needs bandwidth much greater than that permitted for ultrawideband (UWB) applications and operates at frequencies beyond that permitted for UWB under Subpart F of Part 15.

The real regulatory uncertainties facing terahertz spectroscopy with respect to its legality in the US discourages capital formation and R&D. Thus many of the vendors in the US and world market are foreign entities in countries with more supportive spectrum policy structures. A Canada-based client of MSS approached the FCC's Canadian counterpart about a proposed product using terahertz spectroscopy technology to inquire about procedures for authorizing it. Even though a formal request was not made, **within 2 months the firm received clear guidance about what testing would be needed for final authorization of its product for production!**

Clearly terahertz spectroscopy equipment marketing is not and should not be a high enforcement priority at FCC, but uncertainty probably discourage potential investors doing "due diligence".

Terahertz spectroscopy come in two basic types: "time domain" and "frequency domain". Time domain uses a very short impulsive signal to generate a wide bandwidth low power signal in some cases covering 50-400 GHz. Frequency domain usually uses less bandwidth and is usually a swept frequency signal in which some frequency blocks can be notched out. Again, the present terms of US246 are a problem, especially for time domain systems.

Terahertz spectroscopy *might* now be permitted under the archaic terms of Part 18, Subpart C in that the outdated frequency provisions[16] of §18.303 do not forbid the spectrum above 95 GHz and systems on frequencies other than those ISM bands listed in §18.301 appear to be subject to only the field strength limits of §18.305. But the present field strength limits of §18.305(b), 25 uV/m at 300m, clearly were not developed with his in mind, are generally impractical to measure at the stated distance, and depend critically on how to extrapolate real measurements to the stated difference. Indeed, since buildings

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[15] P. Kilcullen *et al.,* "Terahertz Spectroscopy and Brewster Angle Reflection Imaging of Acoustic Tile" *J. Spectroscopy*, Vol. *2017* (2017), Article ID 2134868 (https://www.hindawi.com/journals/jspec/2017/2134868/)

[16] The forbidden bands list of §18.303 is anachronistic in that it includes 500 kHz and 2182 kHz, marine distress bands that were eliminated more than a decade ago but do not provide *any protection* to 1575 MHz, the GPS L1 frequency that has been the object of so much contention in LightSquared/Ligado saga. Indeed a comparison of §18.303 and the parallel restricted band list in §15.205 shows a need for FCC and NTIA to have a more general review of this topic.

Marcus Spectrum Solutions
+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

are basically opaque at these frequencies, it is unclear how that fact should be accounted for.

But absent some clearer statement of FCC policy would anyone really want to invest in a product with such an ill-defined legal basis? We urge the Commission to use this proceeding to clarify the regulatory status of short distance noncommunications uses such as terahertz spectroscopy to end the present gray market for such equipment and to encourage capital formation and R&D for US developers.

This will never be a "killer app" like 5G, but it is a useful technology that can be used in quality control for US manufacturers in production line scenarios to improve US competiveness of US manufacturing. It may conflict with a narrow reading of US246, but isn't that another reason to update US246 since terahertz spectroscopy is not an actual interference threat to the protected passive systems?

Conclusions

MSS congratulates the Commission for the draft NPRM. The above comments are intended to improve the proposals to further US competitiveness in telecommunications, telecommunications technology, and manufacturing.

Sincerely,

/s/

Michael J. Marcus, Sc.D., F-IEEE
Director

cc: Chmn. Ajit Pai
Comm. Mignon Clyburn
Comm. Michael O'Rielly
Comm. Brendan Carr
Comm. Jessica Rosenworcel
Rachael Bender
Louis Peraertz
Erin McGrath
Will Adams
Umair Javed
Julius Knapp
Michael Ha

Marcus Spectrum Solutions

+1-301-229-7714
mjmarcus@marcus-spectrum.com
www.marcus-spectrum.com

Attachment I:
US246 Proposal

Present text of US246:

US246 No station shall be authorized to transmit in the following bands: 73-74.6 MHz, 608-614 MHz, except for medical telemetry equipment and white space devices, 1400-1427 MHz, 1660.5-1668.4 MHz, 2690-2700 MHz, 4990-5000 MHz, 10.68-10.7 GHz, 15.35-15.4 GHz, 23.6-24 GHz, 31.3-31.8 GHz, 50.2-50.4 GHz, 52.6-54.25 GHz, 86-92 GHz, 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, 250-252 GHz. (Footnotes for 608-614 MHz omitted)

Proposed alternative:

US246 No station shall be authorized to transmit in the following bands: 73-74.6 MHz, 608-614 MHz, except for medical telemetry equipment and white space devices, 1400-1427 MHz, 1660.5-1668.4 MHz, 2690-2700 MHz, 4990-5000 MHz, 10.68-10.7 GHz, 15.35-15.4 GHz, 23.6-24 GHz, 31.3-31.8 GHz, 50.2-50.4 GHz (Footnotes for 608-614 MHz omitted)

No station shall be authorized to transmit in the following bands except under strict technical conditions that limit emissions directed towards radio astronomy facilities using these bands or passive satellites complying with ITU allocations that use such bands: 52.6-54.25 GHz, 86-92 GHz, 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, 250-252 GHz. Only fixed terrestrial systems may be authorized in such bands and any use will be on a secondary noninterference basis to the primary passive systems.